

The background of the cover is a dark blue grid with various financial charts. A yellow line graph is prominent in the upper left, showing an upward trend. A candlestick chart is visible in the lower left. Faint numbers like '1.55' and '1.70' are scattered across the grid.

# **OPTION GREEKS**

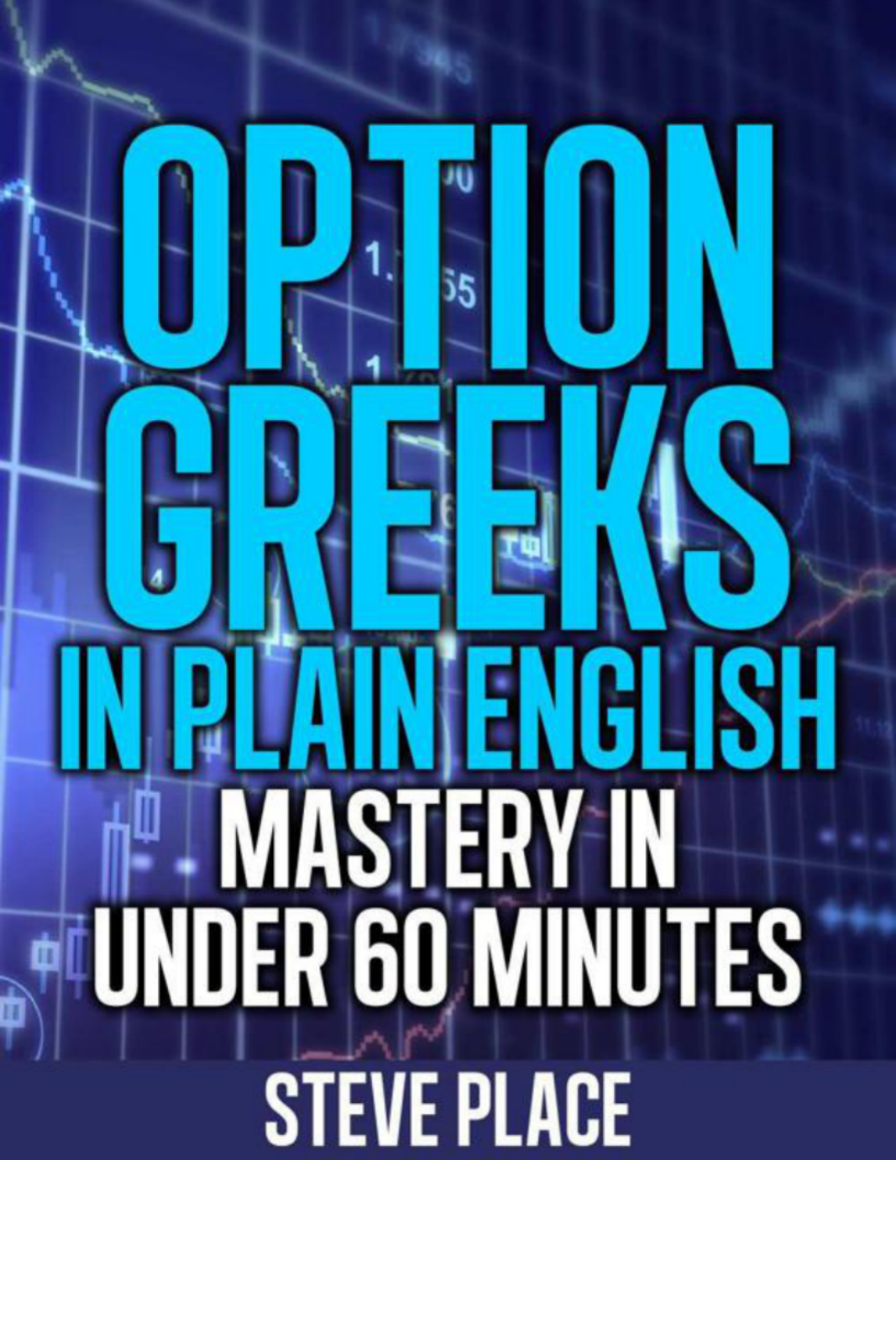
**IN PLAIN ENGLISH**

**MASTERY IN  
UNDER 60 MINUTES**

**STEVE PLACE**

VISIT...

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The background of the entire cover is a dark blue grid with various financial data visualizations. There are several line graphs in light blue and green, some showing upward trends and others downward. There are also candlestick charts in white and blue. Faint numbers like '1.7345', '1.55', and '1.10' are visible in the background.

# **OPTION GREEKS**

## **IN PLAIN ENGLISH**

### **MASTERY IN UNDER 60 MINUTES**

**STEVE PLACE**

# **Option Greeks in Plain English:**

## **Mastery in Under 60 Minutes**

**By Steven Place**

<http://www.investingwithoptions.com/>

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To see a full disclaimer, check out Appendix D

## YOUR FREE GIFT

I want to say *thank you* for picking up this ebook. If you're reading this, you want to become a better trader, and I want to help.

There are many ways that people learn. Some will do well with this text, and others need a different mental pathway. With this in mind, I am opening access to a few training videos for those who purchased this ebook. It will be a "chalk and talk" visualization of the option greeks, so that you will better understand the concepts.

This in-depth video is available through this link:

<http://investingwithoptions.com/option-greeks-video/>

# WHY OPTION GREEKS MATTER

Imagine that it's your first day as a trader or investor. You're excited to get started and make some real money!

So you open up your brokerage software and stare at all the flashy red and green lights on your screen. Looks like fun, right?

From there you randomly choose a stock and buy shares. You do so with no regard to what the company is, their fundamentals, or the underlying market structure.

*Terrible idea - but why?*

**Because you got into a trade without knowing the risks of the trade.**

From a fundamental perspective, it's a good idea to know about the company you're trading--how they make money, whether they will continue to make money, and how fast they are growing.

From a technical perspective, you probably want to know the key price levels where buyers and sellers have been trading.

Whatever your approach or methodology, financial speculation is all about understanding the risks when you put on a position and knowing how to manage the risks.

*But what makes options so different?*

I've helped hundreds of people become better option traders, and one of the key problems I see is that traders don't understand the risks in the options market.

They stare at the red and green flashy lights and choose a stock option to buy or sell without knowing exactly how the market will affect their position.

And then they will say "the stock moved in the direction I expected, but why did I lose money?"

It's because you don't understand the risks.

In any asset you trade, you care about how the value of the asset will move over time.

With most vehicles like stocks, bonds, currencies, commodities and



futures, the only thing that can affect the price of the asset is the change in the structure of the buyers or sellers of that asset.

**Up or down.** That's all that matters. Either the stock goes higher, or the stock goes lower.

But options are a unique asset, because it is a **risk market**, not a capital market. There are other things that can affect the value of an option besides the stock movement.

The things that can affect option pricing are known as "**the greeks**," and that's what this eBook is all about.

By properly understanding the greeks and how option prices move, you will have a better grasp of the risks in the options market, and it will become a better options trader.

The title of this book says you can master the option greeks in under 60 minutes, and I think that's very feasible. The meat of this book clocks in around 9,000 words. Technical materials are read very slowly-- sometimes under 200 words per minute. But even with that, you should be able to fully read and comprehend this book in about under an hour.

Good luck and happy trading!

# HOW TO LEARN THE GREEKS

A major problem option traders face when learning option pricing is that the "textbook method" isn't for most people.

Sure, the option greeks are very well explained in college classes, but they are usually accompanied by something like this:

$$C(S, t) = N(d_1) S - N(d_2) K e^{-r(T-t)},$$
$$d_1 = \frac{\ln\left(\frac{S}{K}\right) + \left(r + \frac{\sigma^2}{2}\right)(T-t)}{\sigma\sqrt{T-t}}$$
$$d_2 = \frac{\ln\left(\frac{S}{K}\right) + \left(r - \frac{\sigma^2}{2}\right)(T-t)}{\sigma\sqrt{T-t}} = d_1 - \sigma\sqrt{T-t}.$$

For those with heavy math backgrounds, that makes sense.

But for most people, this method of learning is entirely too abstract and not really practical in day-to-day operations as a trader.

*Leave the complex equations to the finance undergrads and the computers.*

From my experience as a trader and a teacher, I've found that mastery of the greeks comes through two channels: analogies, and visual references.

These are different neural pathways that we can use compared to the hard math, left-brained side that is ineffective.

This ebook will be full of references to "normal" events like sports and how it carries over into the options market. There will also be plenty of graphs of actual option risk profiles so you can see the greeks as well as hear about them.

## HOW TO VISUALIZE RISK

Way back in the day, floor traders would rely on hand-pressed papyrus and their trusty abacus to figure out the fair value of an option. Option orders were sent via smoke signals and horseback, which led to a very smelly Chicago.

This, of course, is an exaggeration. But relative to the past, the average investor has a lot more computing power in their iPad than what entire exchanges had a few decades ago.

Because of this, we can rely on technology to calculate risk pricing for us and model our risk as a function of price, time and volatility.

This allows you to go beyond the complex math and see the higher-level concepts, which are more important on a practical level.

These risk management platforms are now available with a brokerage account or for a fee-- you can see what I use and recommend in Appendix A.

# SOME COMMON TERMS

Before we can dive into the greeks, you must have a basic understanding of how options are priced.

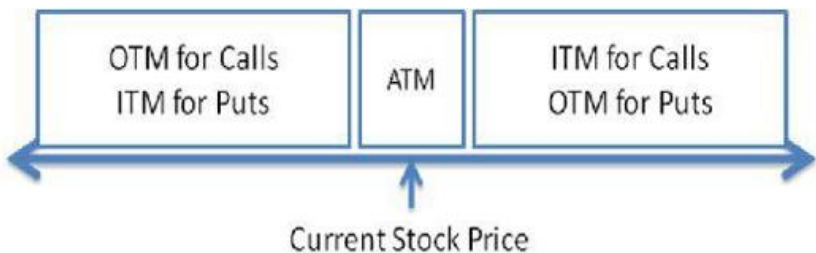
**Moneyness** is a term that tells us what kind of deal we get with an option at expiration.

There are three kinds of moneyness:

**At The Money (ATM)** - This is where the strike price of an option is the same or nearly the same as the underlying stock. A 50 strike call would be ATM if the stock were trading at 50

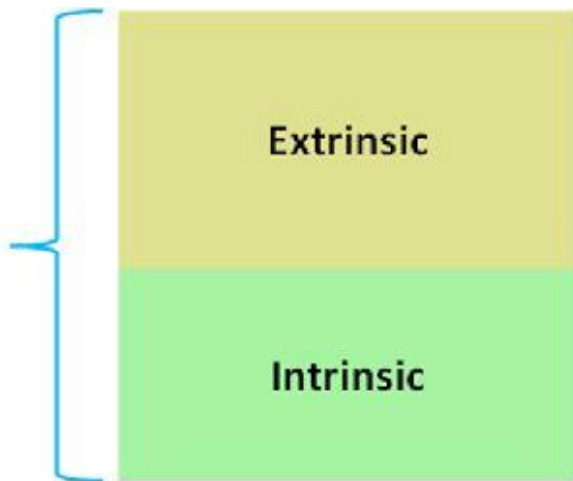
**Out of the Money (OTM)** - This is where it is not advantageous for the option buyer to exercise the option at expiration. If you have a \$40 call and the stock is trading at \$35, it would make more sense just to go buy the stock at the market price \$35 than to use your option and buy it at \$40.

**In the Money (ITM)** - This means it is advantageous for the option buyer to exercise the option at expiration. A \$40 call option would be ITM if the underlying stock is trading greater than \$40 because it would make more sense to use your option to buy the stock at 40 compared to buying it on the open market at a higher price.



Moneyness is key to understanding the two parts to the value of an option.

Option Value



Options have two components in their pricing: Intrinsic value and extrinsic value.

The intrinsic value is how far in the money the option is. A \$50 call with a stock trading at \$55 would have an intrinsic value of \$5.

Keep in mind that not all options have intrinsic value-- only those that are ITM will have intrinsic value.

The extrinsic value is whatever is left over after the intrinsic value is accounted for. This is also known as the "**risk premium**" of the option.

The extrinsic value is what makes options trading fun and profitable, and it's where you will gain an edge in the options market.

The greeks are not just about how the option value will change, it's also about how the risk will change.

The **first order greeks** are those that directly affect the price of an option.

The **second order greeks** are those that affect other option greeks.

We will first take a look at what I consider to be the main greeks: delta, gamma, theta, vega, and rho. These are the easiest to understand and also the most important when considering entering a trade.

From there we will look at forces that can occur on the main greeks-- these are the second order greeks.

# THE BIG BELL CURVE

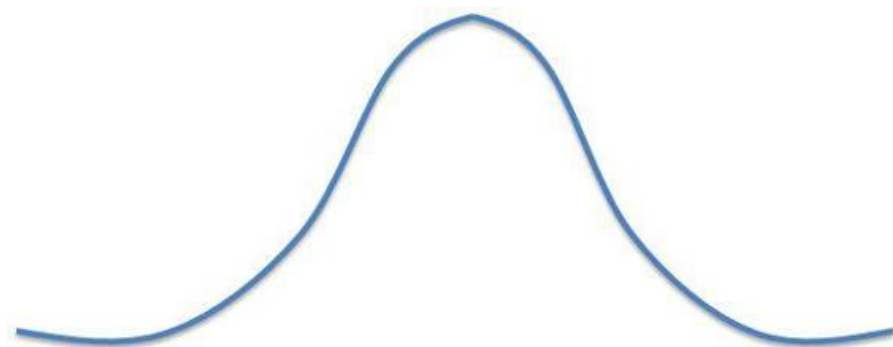
The options market is a risk market. The risk that the market prices in is in the extrinsic value, but how do we define "risk" in the first place?

Stocks tend to move in such a fashion that their daily returns tend to cluster. More often you see 1% days than 5% days in the market.

A clustering of daily change means that the market is a "lognormal distribution." That just means the daily change tends to fit under a big bell curve.

Now we could get all math-happy and show how step functions and geometric Brownian motion can lead us to a binomial pricing model, and how integrating the binomial model somehow gets us to more complex stuff like the Black-Scholes pricing model.

But all we care about is the Big Bell Curve.



The Big Bell Curve is how we derive a lot of option greeks, so you will see it pop up every once in a while.

It is related to what the market is expecting in terms of price action in the future. Sometimes the market gets it right, sometimes the market gets it wrong.

And sometimes the market can change its mind, which means the Big Bell curve can expand and contract.

Don't worry too much about the mechanics just yet-- as we go further on in the book you will see how the Big Bell Curve comes into play with the greeks.

# DELTA

Delta is the first greek we will cover and is the simplest to understand. It is the risk in your position as it relates to the underlying stock.

Consider just buying 100 shares of a stock at \$50. If the stock moves up \$1 point then you have made \$100. Simple right?

That means you have a delta of 100.

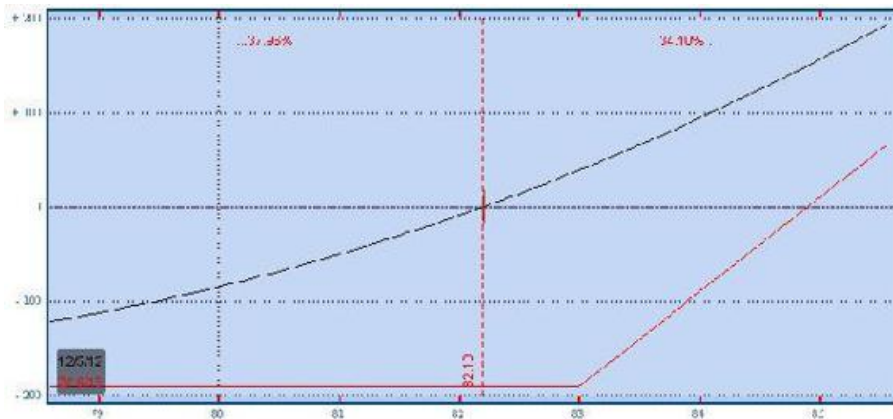
$$\text{delta} = \frac{\text{change in position value}}{\text{change in stock price}}$$

With stock it's simple. Each share is 1 delta, and it will stay at 1 delta until you exit the position.

But with options it becomes more complicated. We're no longer dealing with a "static" exposure, but a dynamic position that changes over time and price (we will get to those greeks shortly). Each option strike will have a different delta, and each option month will carry different deltas.

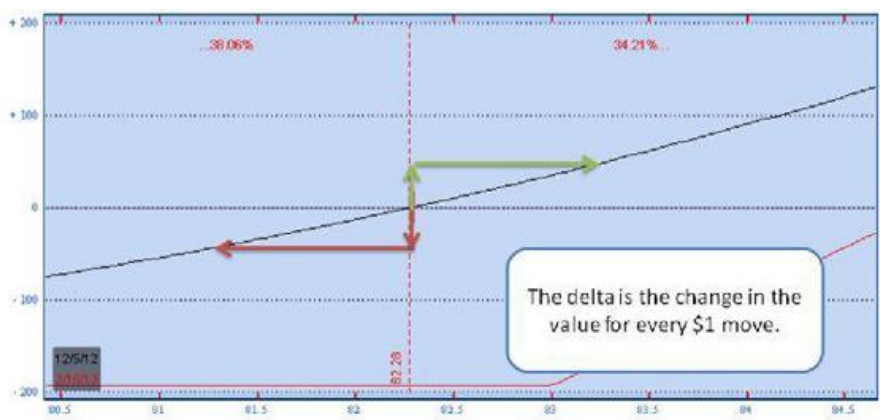
Consider a long call. This is a limited risk, limited reward play that is bullish on the underlying stock.

Specifically we will look at the risk profile of an IWM (Russell 2000 ETF) long call:



The black line is the position value right now (y-axis) as it relates to the stock (x-axis). The red line is the position value at options expiration.

We are going to zoom in on this risk profile a bit and see what happens if we get a \$1 move in either direction:



If the stock rallies \$1, the position will make about \$48.

If the stock drops \$1, the position will lose about \$44.

There are reasons why the drop is not equivalent to the rise- that will be detailed in the next section.

But overall, if the stock moves up or down \$1, then the value of this option will move about \$46 either way-- that means this option has a delta of 46.

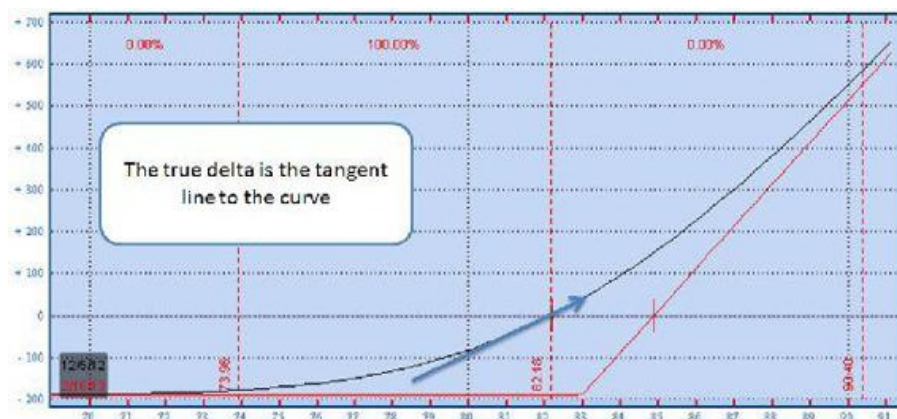
When we visualize it as we did above, the delta can be viewed as a



rise/run relationship-- this is also known as the **slope**.

And when the change gets very, very small, the instantaneous slope will be the **tangent line to the curve**.

That's also a fancy way of saying the delta is the first derivative to the P/L graph.



A good way to approach the delta of an option is to understand how it relates to the odds of the position.

*The delta of an option is (almost) equivalent to the odds that the option will expire in the money.*

An exact at-the-money option has a strike price that is the same as the underlying stock. So a \$50 call option will be exactly at the money if the stock is trading at \$50 per share.

What are the odds that the option will expire in the money?

Keep in mind; we aren't talking about our opinion on the stock, but a statistical one. Given any current price, the market statistics say it's a coin flip higher or lower-- 50% odds.

So the at the money option has odds of expiration at 50%, which means its delta is 50.

What about an option that is deep in the money? If a call option has a strike price of 30 and the underlying stock is trading at 50, it will be very difficult for the option to move out of the money-- it would require over a \$20 move!

The odds of a deep in the money (DITM) option expiring in the

money are very high-- near 100%. That tells us the option delta will be near 100.

Because DITM options have such a high delta, they will behave very similarly to stock, and can be considered if you want to have a "stock-like" position with limited risk.

Now finally, what about an option that is very deep out of the money (DOTM). If a stock is trading at \$50 and the underlying strike is at 70, it would require the stock to trade up more than \$20 for the option to go ITM-- the odds of this happening are very low.

Therefore, a DOTM option will have a very low delta, because the odds of expiration are very low.

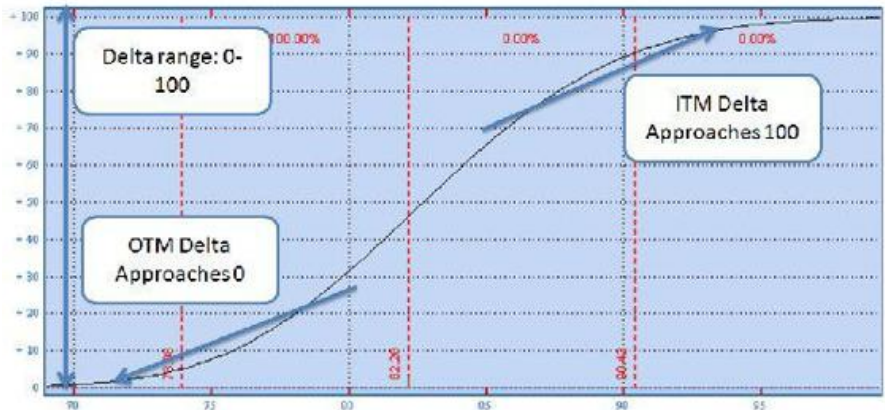
| Option Type           | Odds of ITM Expiration | Delta                          |
|-----------------------|------------------------|--------------------------------|
| Deep out of the money | Very low odds          | Very Low delta – approaches 0  |
| At the money          | About a coin flip      | Around 0.50                    |
| Deep in the money     | Very High Odds         | Very High delta – approaches 1 |

Understanding the relationship between the delta and the statistical odds implied in the options market is a very powerful concept, one that we will approach again.

Another key concept about delta is that the absolute delta of an option will never go above 100 and below 0. Why is that?

Standardized option contracts deal with a unit size of 100 shares, which provides the upper limit. And calls will never have short exposure, because then it would be called a put!

We can visualize the delta of positions as well:



By looking at the picture above, you can see that delta changes as it relates to stock price.

That brings us to our next greek.

# GAMMA

Gamma is the change in the option delta as it relates to the change in the underlying price.

$$\text{gamma} = \frac{\text{change in delta}}{\text{change in stock price}}$$

That may seem like a complicated sentence, but hopefully if you understood the relationship with delta and "moneyness" then you can see how this works out.

If an option is very far out of the money it will have a low delta, because the odds of being ITM at expiration are low. But if the underlying stock moves and the option goes from out of the money to at the money, then the odds of being ITM increase-- therefore the delta increases.

Consider long stock for a moment. 100 shares of long stock will have a delta of 100 no matter if the stock is trading at \$1/share or \$1000/share.

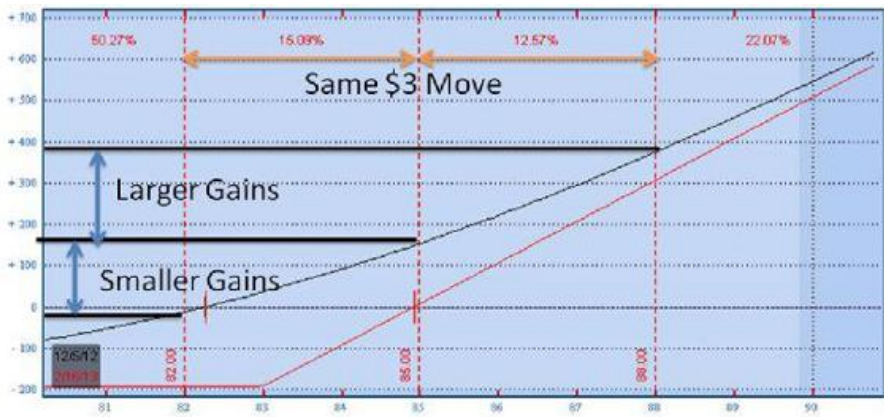
If the delta never changes with stock, it means that stock positions will always have zero gamma.

Let's go back to our IWM long call position again.

This time instead of looking at a \$1 move up or down, we will be looking at two separate \$3 steps. This way we can see the effect of gamma much better.

Let's say IWM moves from 82 to 85-- that's a \$3 move, then you're looking at a change of +\$165 on the option.

But if IWM moves from 82 to 85, the value of the option would increase +\$221 on top of that \$165.



This proves to us visually that the **delta of this option is non-linear**.

When the IWM call is ATM, the delta is 50. If the stock rallies, then the option goes ITM and the delta increases.

This means that your directional exposure *increases* as the stock rallies. That can be fun if you're using leverage-- but there is a tradeoff (more to come on that later).

A great analogy here is with simple physics.

A car travels at a certain velocity, or speed. While the car is at a constant velocity (think cruise control) then you don't feel any external forces.

But if you hit the gas or slam on the breaks, the velocity will change-- the change in the velocity is known as the acceleration.

If you're traveling in a car or a train or a plane with a constant velocity, you don't feel anything. Relative to the thing you're travelling in, it is like you are sitting still.

But if there is acceleration, that's what you feel-- if things accelerate (or decelerate) too fast you end up with a bit of discomfort.

Gamma is the same way-- it's a greek that you can *\*feel\**, especially if the underlying stock is moving very, very fast.

This analogy carries over well into the relationship between value, delta and gamma:

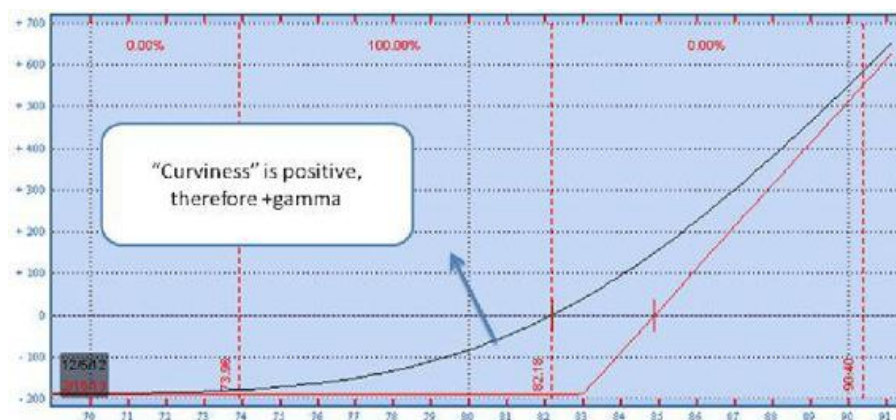
| The Math                   | Particle Physics | Options Trading |
|----------------------------|------------------|-----------------|
| Starting Point             | Position         | Current P/L     |
| 1 <sup>st</sup> Derivative | Velocity         | Delta           |
| 2 <sup>nd</sup> Derivative | Acceleration     | Gamma           |

If an option delta is the 1st derivative to your P/L graph, then the option gamma is the 1st derivative to the delta and the 2nd derivative to your P/L graph.

I promised no heavy math, right? Humor me.

The 2nd derivative of a graph is directly related to the "curviness" of the graph.

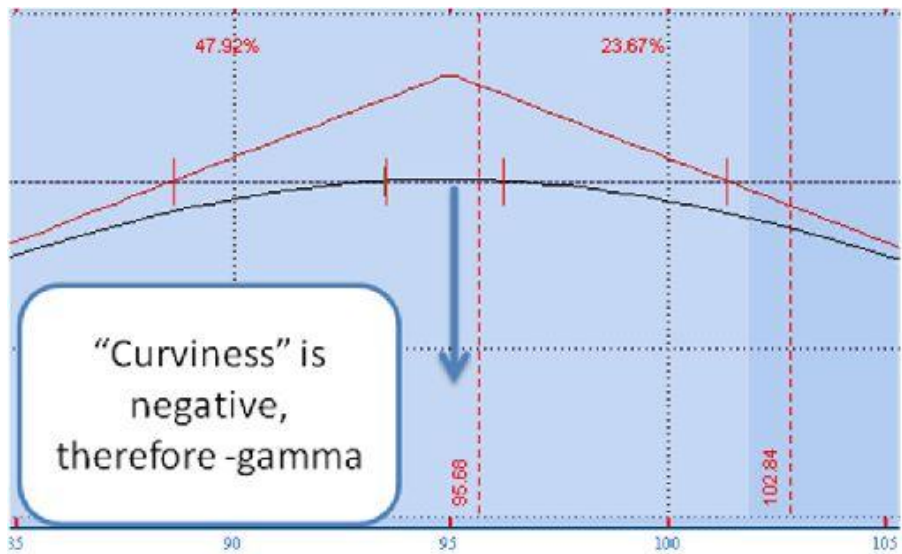
Take a look at the call option again:



Instead of relying on any heavy math, you can simply eyeball a graph to see what your gamma looks like.

You can also be short gamma, where your directional exposure increases on a move-- but it is adverse to you.

A good example of this is what's known as a straddle sale-- this is a combination of a call sale and a put sale.



"Curviness" is negative, therefore -gamma

If you sell an ATM straddle, then the delta of the call and the delta of the put offset each other exactly and you are left with what is known as a "delta neutral" trade. But this is a short gamma trade, which means your delta can change.

If the underlying stock sells off, then you start to accumulate long deltas. If the stock selling continues further, the long deltas cause losses in the position. If the stock sees no mean reversion and the underlying continues to run down even more, you can end up with significant losses.

If you accumulate too much short gamma, then you will experience what I call "**gamma heartburn**," meaning the underlying stock is moving too fast for you to properly adjust your trade and you start to lose money much faster than you planned.

This leaves you with a pit in your stomach, and creates the heartburn.

So why would you even consider getting short gamma-- it doesn't make any sense to do that unless you had some sort of reward to go with your risk!

Which leads us into our next greek...



# THETA

Imagine yourself in Las Vegas, sipping on an overpriced drink and sitting at the casino's sportbook.

With sports betting, you play the "spread," which means the winning team has to beat the opponent by a certain amount of points if you want to get a payout.

But what if you had the ability to bet on the spread *during the game*?

At the beginning of the game, the score is 0-0, and there is a full game to play with plenty of uncertainty. The variance in the outcome is very large.

But maybe at halftime the score is 48-52, which is a spread of 4 points. We don't know what's going to happen in the 2nd half, but maybe we know now that the first team has lost their star forward, and the second team has a shooting guard that is on fire tonight-- with that information and with only half a game left, we have a better idea about the outcome of the game-- and there is only a half left instead of a full game.

The variance in the spread will be lower now than when the game started.

Now consider the game with 30 seconds left, and the score is 99-105. The winning team has the ball and just has to run out the clock. With that little time left, there is not much either team can do to affect the point spread. The variance of the outcome nears zero, until the buzzer ends.

See how as we got closer to the end of the game, the variance continued to decrease? The same thing happens in the options market.

$$\text{theta} = \frac{\text{change in option value}}{\text{change in time}}$$

Options at their core are a **risk management product**.

The option strike price and its relation to where the underlying stock will move drive a key part of the option pricing.



Options will expire at some point, and when they do, the OTM options will expire worthless and the ITM options will have some sort of transaction that occurs at expiration.

Do we know in the future what the underlying stock will do? No, but we have a much better idea of where the stock will be tomorrow compared to where it will be in 3 months.

**The option's extrinsic value is the risk premium in an option-- it is related to the odds that the option will expire ITM.**

Options will always have extrinsic value until they expire, because there is always going to be risk in the market until the time runs out in the contract.

But as we get closer to the buzzer, the expected variance decreases, which leads to a decrease in the extrinsic value and the option value overall.

The loss of value over time in the option is known as the **theta** of an option. It is the amount of decay per day in the options' extrinsic value.

**Long options will always be short theta, and short options will always be long theta.**

# THE BIG TRADEOFF

Remember how it didn't make sense to take on short gamma risk without some sort of reward?

The reward is theta. If you are short gamma that means you are long theta-- you make money over time.



This is the major tradeoff on whether you want to be an option buyer or an option seller.

If you are an option buyer, that means you are putting on long gamma trades looking for an acceleration in the underlying stock, regardless of what direction you choose. In exchange for this opportunity, you end up with short theta, which means if the stock doesn't see that move over time, then you will start to lose money on your position.

An option seller is someone who is short gamma and willing to assume risk of large movement, because they think that the risk of large moves is not as great as what the options are pricing in. In exchange for that short gamma, they end up getting long theta, which allows them to make money over time.

So what is better? Long options or short options?

There's no right answer to this and it requires a ton of context. For some trades, it makes sense to be the option buyer, for others the seller.

But there's one thing I know for sure: there is no way to be long theta and long gamma in the same position. If you find it, then you have hit the jackpot and should start a hedge fund.

For us mere mortals, we will always have to work with this tradeoff.

## VEGA

I have friends who are straight up "soccer moms"-- they are in their mid 30's, have 2.2 kids and a mortgage. They drive some form of beige or silver minivan at hilariously slow speeds. They haven't been in a car accident in over a decade and only have that one parking ticket that they got in front of their favorite bikram yoga spot.

I also have a few friends who are the "hot shots"-- and own some form of sports car they drive way too fast. They're single and still in their mid 20's. They text and drive. A few fender benders, maybe a totaled car a few years ago. And they show off their speeding tickets like a badge of honor.

Let's say they both go looking for car insurance. Who will pay the higher premiums?

**The riskier one of course.**

The same thing happens in the options market-- not all stocks have the same risk pricing. An early stage biotech company with an upcoming FDA event will have different risks than a multibillion dollar utility company.

The options market is a risk market. When there is a higher perception of risk, the market places higher odds on options going ITM. This perception of risk is priced into the options through the extrinsic value, from which we derive a reading of "**implied volatility**" (IV).

If you need a quick primer on how implied volatility works, check out my blog post here: <http://investingwithoptions.com/blog/2012/01/04/implied-volatility-guide-video/>

So we know that the IV can change, and we know the IV is derived from the option value.

Therefore, **the option value can change as the perception of risk changes**. This is the greek known as **vega**- it is the sensitivity of the option pricing to changes in implied volatility.

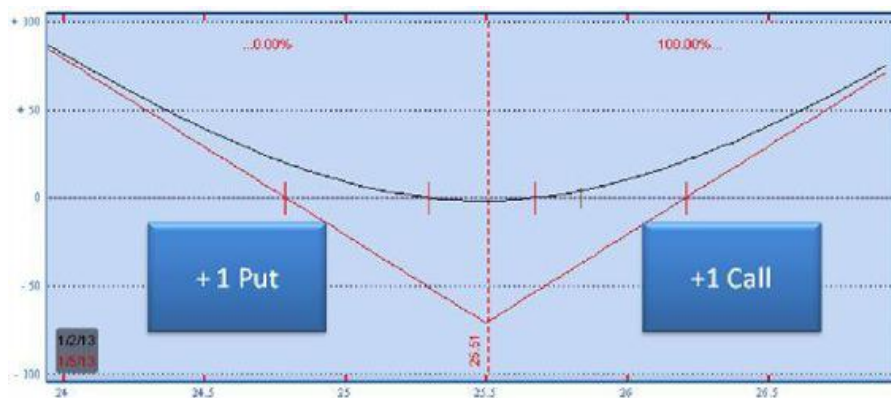
$$\text{vega} = \frac{\text{change in option value}}{\text{change in implied vol}}$$

If a stock has been in a slow trading range that's super boring, the options market will have a low implied volatility because the expectation is that the stock will trade in a very small range. Low implied volatility means low demand for the options, which means low pricing in those options.

But what if that stock all of a sudden collapses because their main product is being recalled?

This is the market's "holy shit" moment, and the perception of risk significantly increases because we don't know if the recall is unfounded or if the company is going bankrupt because of it. Because of a higher risk, the stock has moved from "soccer mom" mode to "hot rod" mode, and the IV spikes higher. Demand rises for options and the value of the options increases across the board.

A good way to look at long vega is an ATM straddle.



This is a combination of a long call and a long put. And because the call and put have the same delta magnitudes, it is a delta neutral trade.

Now if there is no price movement, but the perception of risk changes, what will it do to the long straddle? The extrinsic value in the call will rise **and** the extrinsic value in the put will rise-- vega movement doesn't care about the direction of risk, just that the risk rises.

# RHO

Rho is the red-headed stepchild of all the other option greeks.

And to be honest, it doesn't really matter, for now.

$$\text{rho} = \frac{\text{change in option value}}{\text{change in interest rate}}$$

Rho is simply the change in the option price as it relates to the risk-free interest rate.

## How This Works

This has to do with how options are priced-- the cost of carry comes into play.

With options we can take a stock-based position and convert it into an option-based position.

For example, a protective put is a combination of a long stock position coupled with a long put.

A long call has the exact same risk parameters.

But the long call requires only 10% of the capital to put on the trade. Since this frees up capital, you could put the extra cash into new trades, or just plow it into an account that pays the risk free interest rate.

If interest rates weren't taken into account with options pricing, then there would be a way to completely arbitrage the risk free interest rate. The market, being pretty efficient, won't let that happen.

Either way, rho doesn't really matter until the US Federal Reserve raises interest rates, which at the time of this writing is about 3 months from never.

# THE SECOND ORDER GREEKS

Imagine if you were long 100 shares of AAPL one day and then 500 shares the next day. You'd get pretty nervous, right? And confused! How the heck did your directional exposure change that much?

Many new option traders go through that same trading problem in options, because they don't understand what could change the risks in an option position.

Now we get into some of the deeper "voodoo" behind options, because it requires an extra dimension in thinking.

A **Second Order Greek** is something that affects another greek rather than the price of the option.

We've already discussed one second order greek: gamma-- it is how underlying price movement affects the delta (another greek).

Second order greeks are just as important to understand because they can significantly affect how your position will trade in different environments.

There are essentially 3 things that can change a greek-- underlying price movement, implied volatility, and time.

The chart below shows the main greeks-- and lists the matrix of what can affect them.

Also note that 2nd Order theta greeks don't have any set names. As of this writing I couldn't find the "official" names, and we can just make them up as we go along.

| Greek | Change Over Price | Change over Time | Change over Implied Vol |
|-------|-------------------|------------------|-------------------------|
| Delta | Gamma             | Charm            | Vanna                   |
| Gamma | Speed             | Color            | Zomma                   |
| Theta |                   |                  |                         |
| Vega  | Vanna             | dV/dt            | Vomma                   |

Now we will step through each major greek and we will see how each of these changes affects the greek.

## DELTA - CHANGE OVER PRICE

This is known as the **gamma**, which we have discussed already in detail.



# DELTA - CHANGE OVER TIME

This is known as "delta decay," or **charm**. And it isn't the same for every single option.

$$\text{charm} = \frac{\text{change in delta}}{\text{change in time}}$$

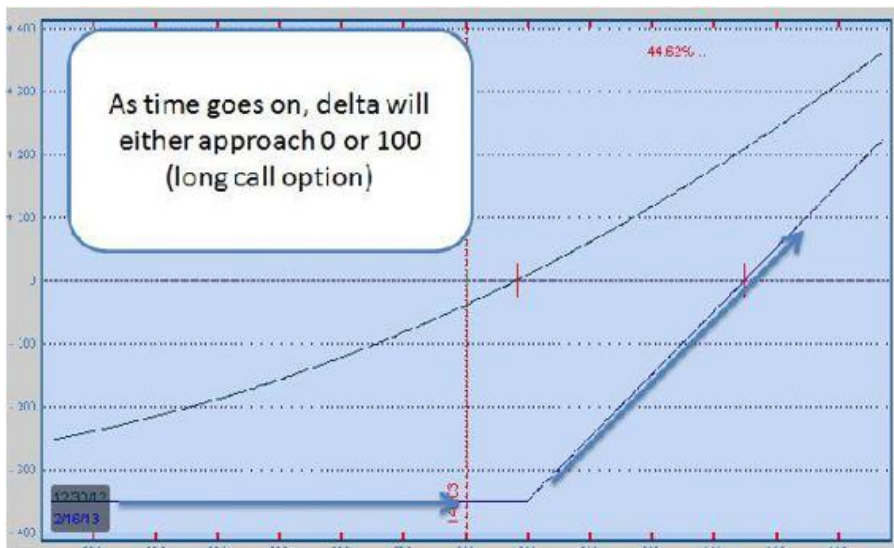
Remember, the delta of an option is roughly related to the odds that the option will expire in the money.

Now consider an out of the money option. Does it have a higher chance of expiring ITM with 3 months of time left or 1 day? The former of course; more time means more potential price movement, which increases the odds.

The converse occurs with an in the money option-- as expiration approaches, the odds that the option will be in the money continues towards 100%, or 100 delta.

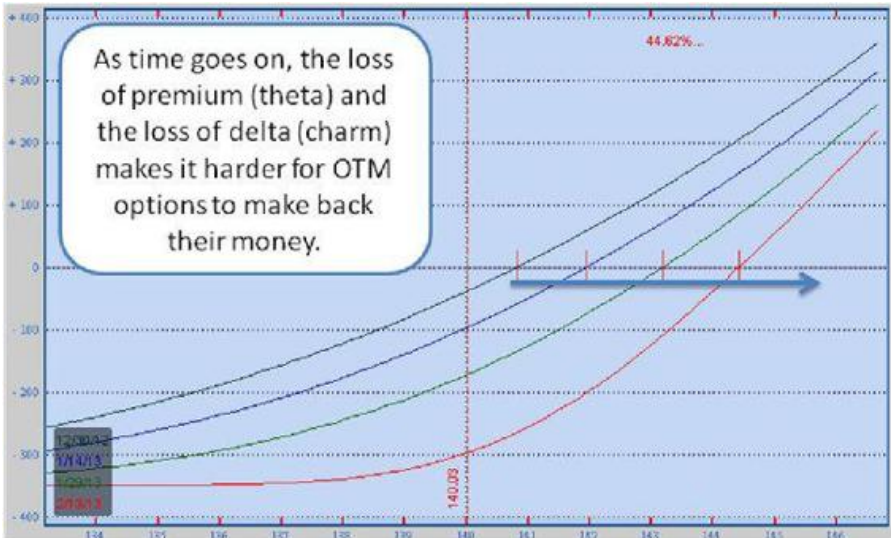
This can also be viewed by looking at risk profile of a call option, comparing the delta today and the delta at expiration.

At options expiration there are two outcomes for delta: either a delta of 0, or the delta of 100.





As time goes on, the loss of premium (theta) and the loss of delta (charm) makes it harder for OTM options to make back their money.

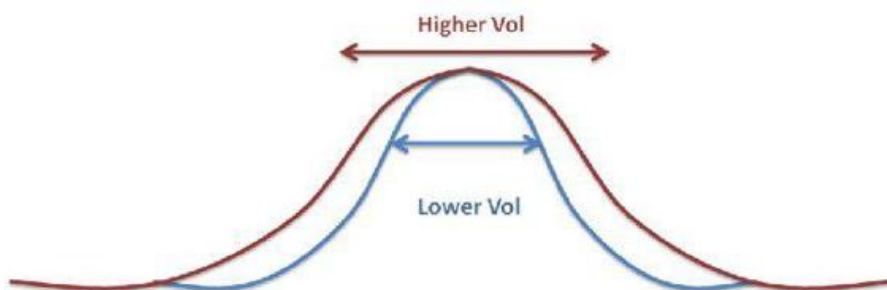


## DELTA - CHANGE OVER VOL

This greek is known as **Vanna**. I guess someone likes Wheel of Fortune

$$\text{Vanna} = \frac{\text{change in delta}}{\text{change in IV}}$$

Let's go back to our big bell curve-- it is related to the expected movement of the underlying stock over time.



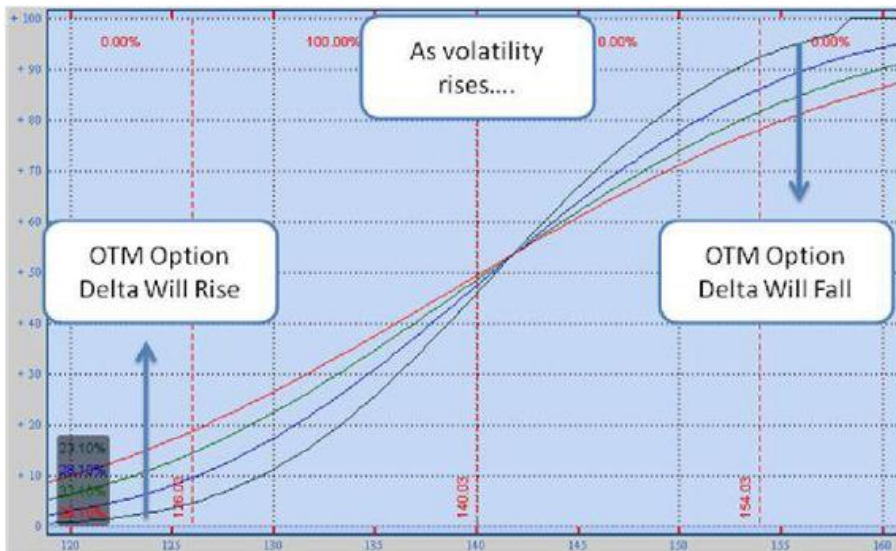
In lower volatility environments, the expected price action is much smaller-- that means the perception of a big move is lower, and the OTM options have lower delta.

But if a higher volatility is priced in, those OTM options will see their deltas (and premiums) rise! Why is that? Because the market is pricing in a higher odds that the underlying stock will move to that strike compared to a lower volatility instrument.

The same thing happens with the ITM options. If the implied volatility in a stock rallies, it's no longer a guarantee that ITM options will stay ITM-- so the odds, and therefore the delta, decreases as volatility rises.

Do note that the ATM options will always have a delta around .50, so their delta is not nearly as "volatility sensitive" compared to OTM options.

We can view this by looking at the delta of a long call option as a function of changes in volatility.



## Why This Is Important

This has significant ramifications for net option sellers.

If you are short a put, you are taking on risk in exchange for the premium of the put. You make money if the underlying stock stays above your short strike.

It is a long delta, short gamma, and short vega position.

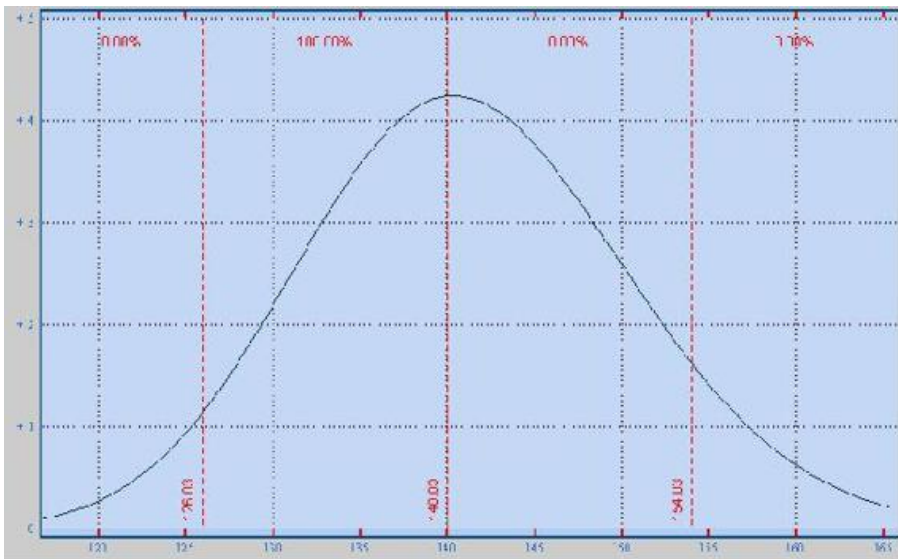
If this is an OTM option you are selling and implied volatility rises, not only will your position suffer because of the vega exposure, but your position will now be much more sensitive to price changes in the underlying. If you are trying to make money from a "non-move" in the stock, this can become an issue as your planned delta risk becomes greater than what you had anticipated.

# GAMMA - CHANGES OVER PRICE

This greek is the **Speed**. Of an option position, which makes little sense because speed (velocity) is the 1st derivative of a particle's position, and option speed is actually the 3rd derivative.

$$\text{speed} = \frac{\text{change in gamma}}{\text{change in stock price}}$$

Below is a chart of the gamma in a call option:



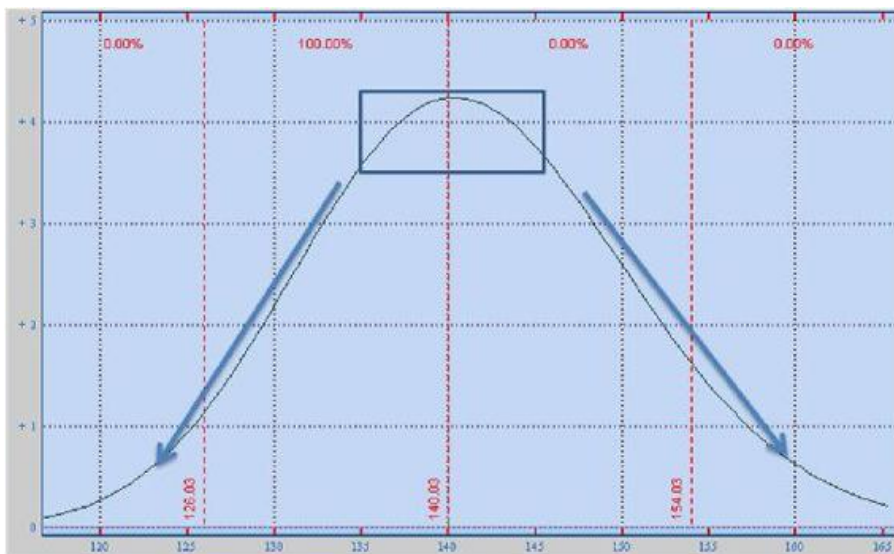
(This looks awfully similar to our "big bell curve" right? They're related-- see Appendix B for a more detailed explanation.)

Remember how we figured out that the delta was just the slope of the p/l line?

And that gamma is the slope of the delta line?

Well speed is simply the slope of the gamma line. It is the change in the gamma as price moves.

So just by looking at the slope we can figure out the value of the speed:



There are three things we can conceptually grasp by eyeballing the slope:

1. As the option goes OTM, the gamma is reduced.
2. As the option goes ITM, the gamma is reduced.
3. The gamma is maximized around the ATM strikes, but doesn't change a whole lot unless it starts to go ITM or OTM.

The actual quantity of speed is not important here-- it's understanding how the gamma will act as price moves.

## Why This Matters

We've talked already about "gamma heartburn." This concept is centered on short option strategies like spread sales and iron condors. If you sell OTM options and the options move to ATM, which means your gamma has significantly increased.

If your gamma has increased, it means your delta sensitivity in your position has rocketed higher-- in the wrong way you want it to go. Net short deltas get more net short and vice versa for longs.

This leads to an unholy storm of risk, which is something that gives me heartburn whenever I sell options that go against me big time.

This is why it's imperative to be very, very proactive when selling options-- knowing how to roll options and hedge your delta and



gamma, all while keeping the cost of the trade very low.

This concept also applies to *option buyers* as well. If you like to trade single stock options, you have to choose the right strike price.

Choosing the right strike is all about getting the best "bang for your buck." Long options are not about maximizing your overall delta-- if you wanted to do that you would trade the stock!

Long options are about maximizing your gamma as it relates to the cost of the option.

If you always buy ATM options but the underlying stock moves very fast in your favor, it would have been a better trade to go a little OTM as it costs less and the gamma would have "accelerated" favorably in your position.

But if you go too far OTM, then you have greater theta risks, and the risk that the gamma will never come.

It's a tricky game, and there isn't always a single right answer-- but understanding how the gamma curve works is a hidden talent that you can use in your trading.



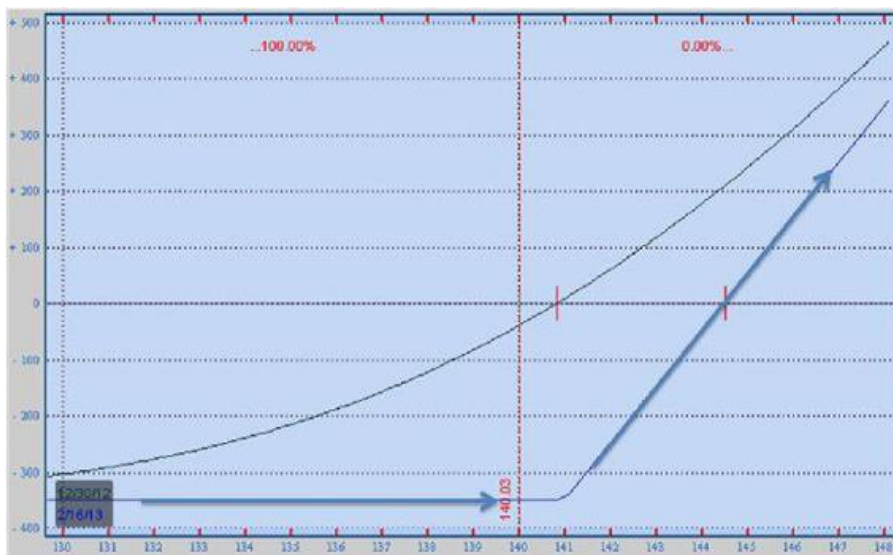
# GAMMA- CHANGES OVER TIME

This greek is related to charm, and it is known as **color**.

$$\text{color} = \frac{\text{change in gamma}}{\text{change in time}}$$

This is a little tricky to explain because it requires a few more steps graphically to arrive at our conclusion.

Let's first look at a p/l graph of a long call option today vs. expiration:



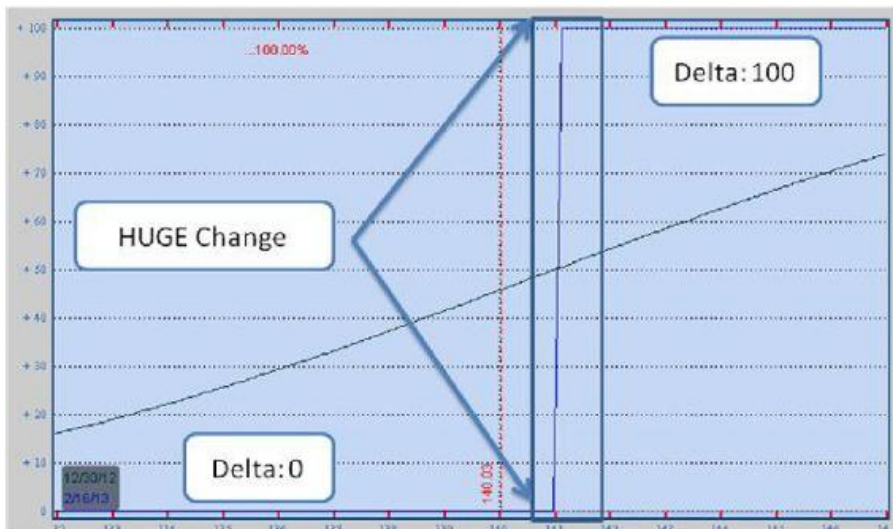
On a long call with plenty of time left, the delta is an ever changing, dynamic thing. If the delta is always changing, then the gamma (change in the delta) will always be a non-zero number.

However at expiration, there are two possibilities: OTM options will have a delta of 0, and ITM options will have a delta of 100.

They don't change. That means gamma is 0 at expiration.

Except... and this is where it gets interesting.

Let's back up for a second, and just look at the delta at expiration:



So delta is at 0 or 100, except this area where the delta has a theoretically instantaneous change.

Now I'm going to have to geek out for a second.

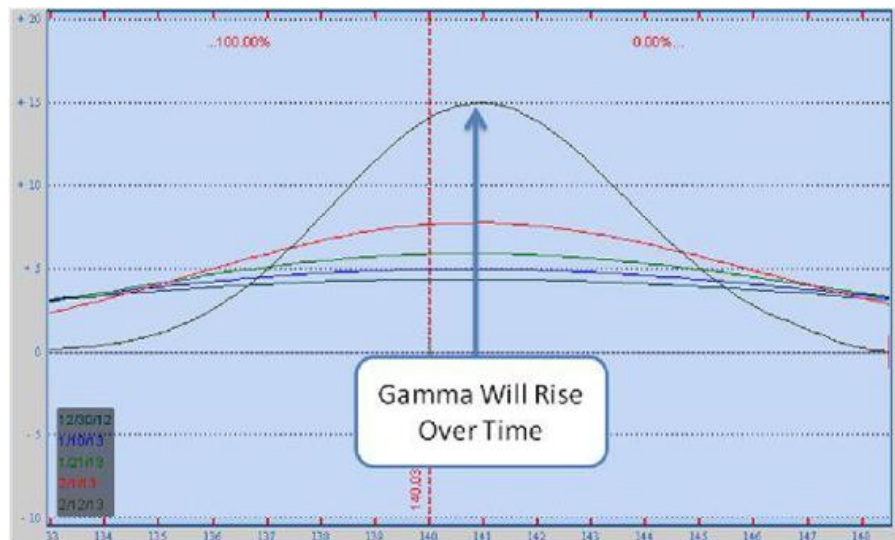
In electrical systems, you have 1's and 0's... theoretically.

But when you turn on a light switch or any other circuit, some funny things can happen-- electricity is not an instant on effect.

There's a fancy term called the "hysteresis" which says that the system can be dependent on past events when it changes its state.

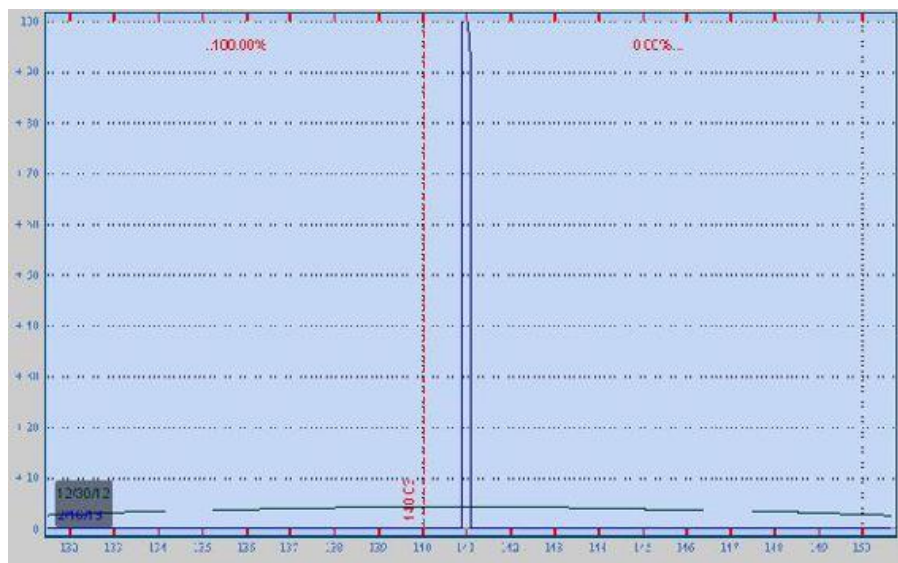
Well this hysteresis area is the transition between having no exposure in a stock and having 100 shares of exposure. It's a massive variance in your delta.

Let's take a look at gamma over time:



As time goes on, ATM option gamma will rise exponentially, while ITM and OTM gamma approach zero.

Here is what the gamma looks like at expiration:



The ATM gamma goes through the roof!

Remember, the gamma is related to the "big bell curve" and the statistical expectations of the underlying stock. As the time nears 0, the expectation will reach a single number-- the entire probability will be centered around a single area.

This graph is also known as a Dirac function, or an impulse function. So when options get very close to expiration, we hit what I call the gamma impulse function.

It's also what I so lovingly call the gamma knife edge.

### **Why This Is Important**

If you short options around the gamma knife edge, you could end up with more than gamma heartburn-- you could land too hard on the knife edge and end up getting cut up way too much.

Options have an incredibly high **outcome variance** as we get closer to expiration. You can easily see 300%+ swings in an option's value in a few hours.

If you want to trade weekly options or trade near options expiration, then you **MUST** know about the gamma knife edge. It's what makes trading long options around opex so powerful, because you can end up with a ton of exposure for a very little cost.

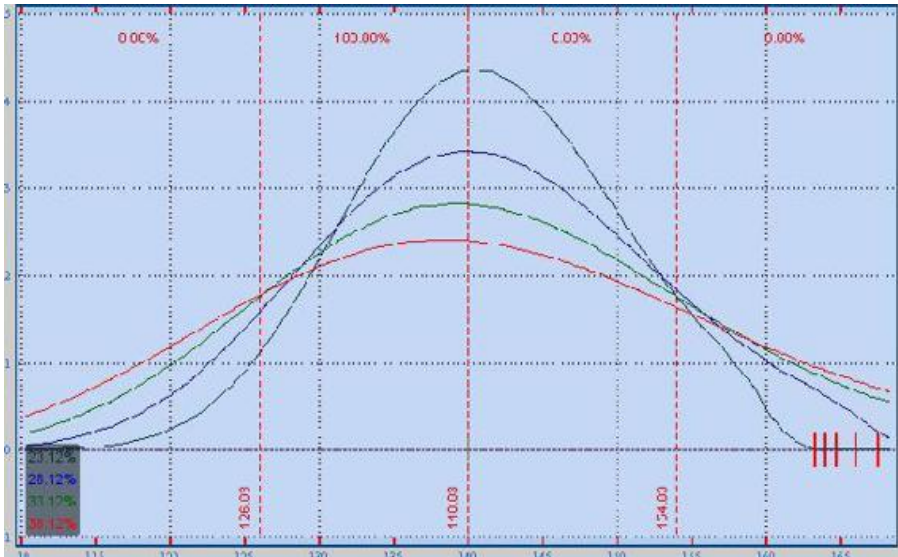
It's also why it is a good idea for more conservative investors to stay away from the gamma knife edge as it creates a much higher portfolio variance.

# GAMMA - CHANGES OVER VOL

Gamma's sensitivity to volatility is known as Zomma, which sounds like it is straight out of a Buck Rogers comic book.

$$\text{zomma} = \frac{\text{change in gamma}}{\text{change in vol}}$$

Below is a chart of the gamma as a function of volatility:



Do note that we are looking at the SPY and pricing in massive moves in IV -- this is simply to illustrate extremes.

Remember-- the gamma is directly related to the bell curve.

The higher the perception of risk the wider the bell curve will be.

That means on a rise in implied volatility, the gamma tends to "spread out" over the strikes. An ATM option will tend to stay around 50 deltas, but OTM options will have a much larger delta variance.

## Why This Is Important

In higher volatility names, you can get a similar amount of gamma

for a lower cost. On a low beta stock like MCD or WMT, buying OTM options don't really have a good "kick" because the gamma is so low.

But with higher beta names like AAPL, GOOG, BIDU and others, you can get away with picking up further OTM options because the gamma on the ATM option and the options a few strikes OTM are going to be pretty similar.

# THETA - CHANGE OVER PRICE

Here's a cool little trick.

**Gamma is effectively the inverse of theta**, and they tend to correlate in terms of magnitude.

So if you have a high gamma, you will also have a high theta.

All the concepts we just covered with gamma? Just take the opposite and you end up with how theta works around these options.

But because theta can be approached from a different angle, it gives us the opportunity to approach the concepts in two ways.

The chart below was a measurement of the extrinsic value in AAPL options on a single month.



Think about this in terms of common sense:

If there is no extrinsic value, what will the theta be?

*Zero* of course. Theta is the decay of the extrinsic value and if there is none, there is no theta.

We can draw this conclusion: the higher the extrinsic value, the higher the theta.

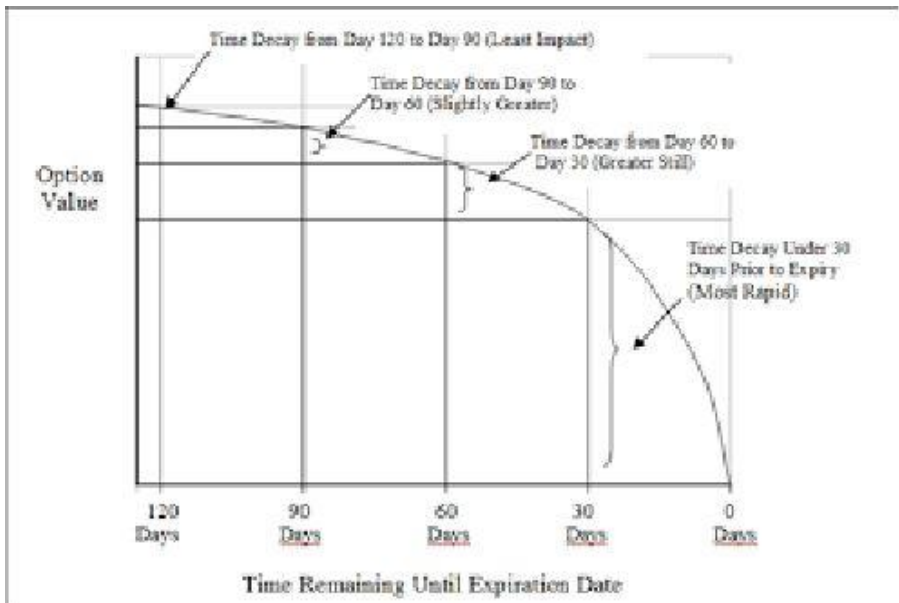
And since ATM options have the highest extrinsic value, they will have the highest theta. As we go further OTM or further ITM, extrinsic declines and therefore theta declines.

Keep in mind that we are talking in absolute terms. Often OTM options will have a much higher theta as a percentage of the total value, which must go into your risk analysis when considering a trade.



# THETA - CHANGE OVER TIME

If you read anything on theta, you're going to see this picture:



This shows us that the time decay of extrinsic value is an exponential function.

It makes sense intuitively: the uncertainty of where a stock will be tomorrow is much, much smaller than the uncertainty one month from now.

The exponential nature of theta is also baked in due to how options are priced-- they assume lognormal distributions-- again, related to our bell curve.

This means the difference in expected price action between 1 month and 2 months will be much higher than the difference between 6 and 7 months.

## Why This Matters

So if the theta is greatest right at expiration, that is where you want to sell options, right?

Not so fast.

In financial speculation, there is always a tradeoff between risk and

reward.

If you want higher rewards, you will have to take higher risks.

If you want higher odds, you'll have to take lower rewards.

The same thing applies in the relationship between gamma and theta.

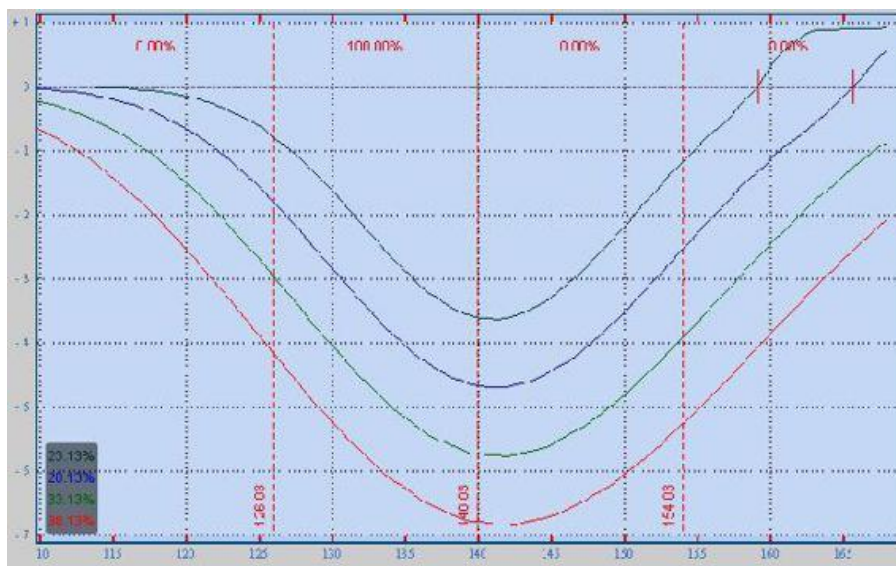
**Want higher theta rewards? You'll have to accept higher gamma risks.**

Want super fast gamma? You'll pay for it with theta risk.

Again, there is no "right" answer here-- there are many different styles and risk profiles for traders to follow. But one thing is for sure-- you can't blindly follow "fat theta" or "fat premium" as a way to put on new trades.

# THETA - CHANGE OVER VOLATILITY

Here is a chart of theta as a function of volatility:



With this chart we are more focused on the magnitude. So when I say "higher," I mean in absolute terms.

Now if you have been following along, we've been viewing gamma and theta as two sides of the same coin-- they trade inverse each other but run together in magnitude.

But if you compare the theta vs. volatility and the gamma vs. volatility, the magnitude rises for the first and shrinks for the second.

What gives?

There's probably a fancy way to prove it by reverse engineering the option pricing models, but just think about it intuitively:

As shown earlier, if there is higher extrinsic value, then there is higher theta.

If implied volatility rises, that means the extrinsic value rises.

If the extrinsic value rises then there will be higher theta.

Simple.

## **Why This Matters**

As to applications, it ties back into the risk/reward equation.

If you want to play the high volatility, fast names, you're going to be paying up in terms of absolute theta.

There's always a tradeoff.

# VEGA - CHANGE OVER PRICE

In my opinion risk analysis as a function of volatility is more important for global derivatives desks compared to smaller retail players. More advanced strategies like volatility dispersion trading and market making require more attention to changes in vega.

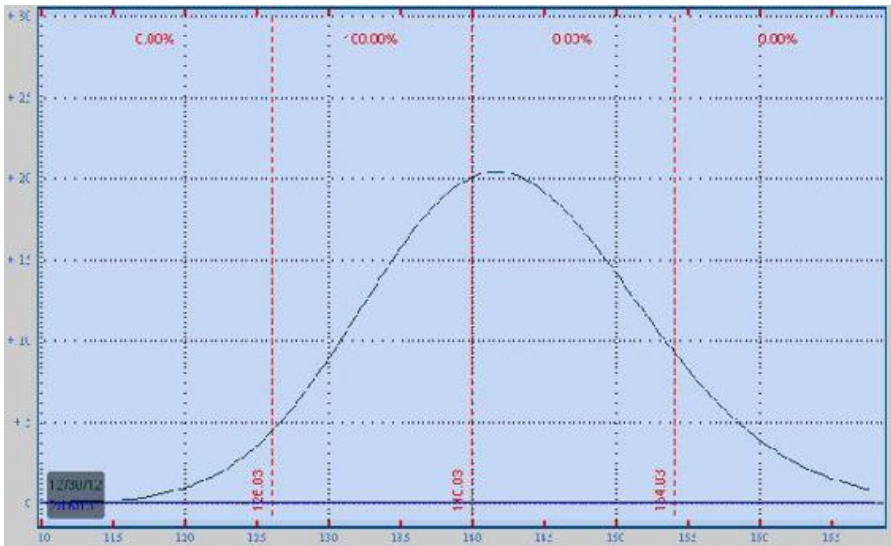
$$\text{vanna} = \frac{\text{change in vega}}{\text{change in price}}$$

Vega as it relates to price is known as **Vanna**. We've already talked about vanna, right?

That's because they are interchangeable mathematically. Don't ask me to prove it, they just are.

Remember: don't get vega and implied volatility confused, it's very easy to do that! Vega is the sensitivity in the option value to changes in implied volatility.

Vanna is the change in vega over price. Here's what it looks like:



Back to the "big bell curve" again.

Remember how theta is highest where extrinsic value is the highest?

It's the same thing with vega. ATM options will have the highest extrinsic value, and since vega only affects the extrinsic value, the highest vanna will be with ATM strikes.

### **Why This Is Important**

This means if you're keen on taking a straight up short vega position, the ATM options will be the highest possible vanna available.

But again, these options will have the highest gamma, so the short gamma risk would be the tradeoff to any short vega exposure.

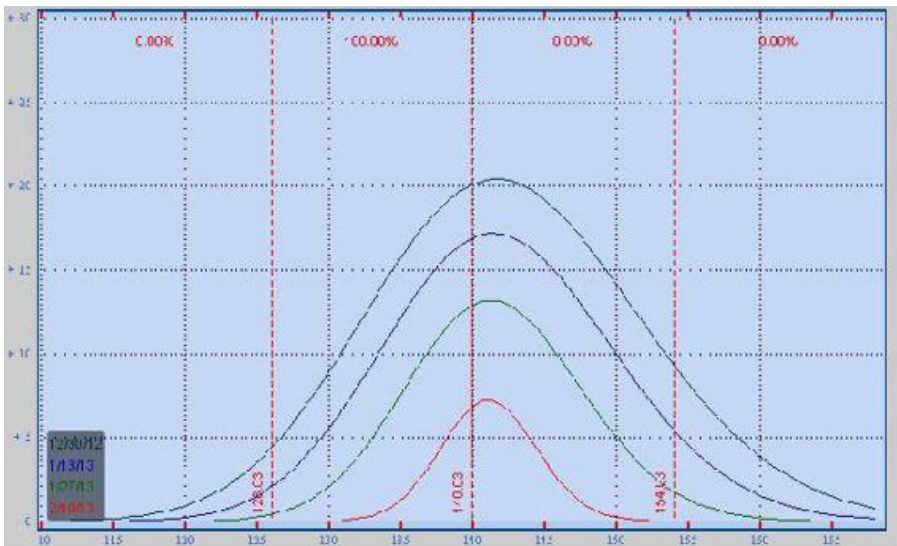
As another quick sidenote: not all volatilities are the same. The ATM options will have a different IV compared to OTM options-- this is known as the option skew. If you want to trade volatility, you can't just blindly look at vega but you must also consider volatility skew and term structure.

# VEGA - CHANGE OVER TIME

This greek is known as **DvegaDtime**, because option traders got tired of being clever with their naming.

$$\text{DvegaDtime} = \frac{\text{change in vega}}{\text{change in price}}$$

If the vega chart looks like a bell curve, can you guess what it will look like when we view it over time?



As time goes on, the sensitivity to changes in implied volatility decreases in all options. Putting aside the math, this makes sense as the extrinsic value becomes driven more by time (theta) than vol (vega) as we get closer to options expiration.

## Why This Is Important

If you trade a ton of calendars, you must understand that volatility sensitivity will be different in front month vs. back month options (you will also have to consider term structure). There are also some fun things that you can do with short term options, volatility sensitivity, and earnings/FDA events.

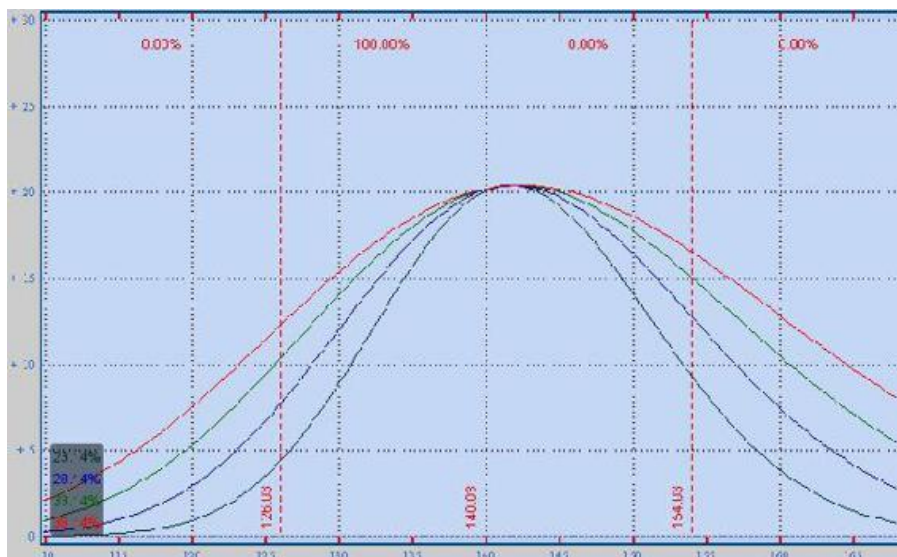
# VOLATILITY - CHANGE OVER VOLATILITY

Now we are getting into a strange loop.

$$\text{Vomma} = \frac{\text{change in vega}}{\text{change in IV}}$$

Vega is the sensitivity to volatility, but how will that sensitivity act as IV moves? This is known as **Vomma**.

Let's take a look at a chart of vega as implied vol expands:



For ATM options, it does nothing. The vega sensitivity remains the same no matter what the IV reading. This probably is related to why ATM options have a delta/odds around 50 regardless of time or vol.

But if you go further OTM or ITM, the vega rises as implied volatility rises.

We can go back to our analogy: more extrinsic, more vega. So if IV rises, the extrinsic in all options will rise, therefore the sensitivity to vol will rise as well.



## **Why This is Important**

For short option players, this can be akin to the gamma heartburn I mentioned earlier. If you are short volatility, and IV rises, not only will you lose money on the vol rise, but you will also increase your exposure to said vol through the increase in vega. If vol explodes (combined with your short gamma), things can get ugly in a hurry.

This is where it may be helpful to learn the importance of managing risk as a function of vol-- using unit puts to protect downside, or if the portfolio is right, trading VIX options and futures to hedge off some overall vega.

## PUTTING IT ALL TOGETHER

If you have never traded an option before, this may seem a little overwhelming.

Well, stop worrying.

On a practical level, a higher-level understanding is needed-- very rarely do you have to dive this deep into every single greek to manage a trade. Most option trade structures are very simple to understand, and "tail risks" on second order greeks rarely occur.

With an understanding of the greeks, you can go beyond knowing what your risk is in an open position-- you can now structure a risk on a trade before you put it on, fully aware of *all* the risks you are taking. From there you will develop yourself into a happy, healthy, profitable options trader.

# THANK YOU

Before you wrap up reading this eBook, I'd like to say "thank you" for purchasing this, and I hope it was a great investment in your financial education.

I know there are a ton of resources out there and it's hard to find good quality education.

So a big thanks for picking up this ebook and reading all the way to the end.

If you like what you've read, then I'd love a review.

Please take a moment to let me know what you thought of this book on Amazon:

<http://www.investingwithoptions.com/greek-ebook/>

This feedback will help me write the kinds of Kindle books that will make you a better trader.

## APPENDIX A -- SOFTWARE

In this book, we use analytics software for visual demonstrations.

Having access to this software to interact with different risk structures will give you yet another learning conduit for understanding how the greeks work.

The software screenshots in this book were from the brokerage platform of **thinkorswim**, which is now owned by **TD Ameritrade**. This is still one of the best solutions out there, and it is free as long as you have an account.

There are a few other solutions out there for analytics.

**LiveVol Pro** - This is a slick web application that came out a few years ago and I've been hooked since. This does cost money, but you can get access to the software if you open an account with their brokerage arm.

**OptionsOracle** - This is free software that you can use to build out potential trades, and it interfaces with Interactive Brokers. You can get it at [samoasky.com](http://samoasky.com)

**Derivix** - This software is geared more towards institutional investors, but is a very powerful platform. Learn about it [here](#).

## APPENDIX B - SOME HEAVY MATH

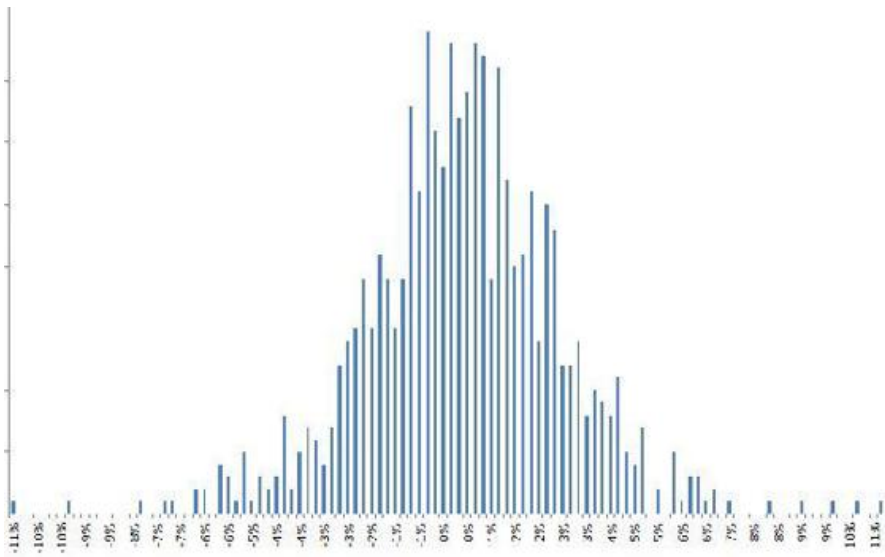
For those mathematically inclined, prepare to have your mind blown. For the entire text I attempted to simplify the greeks into easy to understand concepts and analogies.

But if you have a background in statistics or calculus, or you want to get more into the nitty gritty of option pricing, this is a good starting point.

The option pricing models we use make a few key assumptions.

First: stocks tend to have lognormal distributions-- this means that the price change day to day will fit under a bell curve.

For example, here is a histogram of the daily price change in AAPL from 2005 to 2008:



This is our big bell curve, meaning that there is an expected distribution of returns over time, and it's what the option market implies in the future.

But what do we mean by "implied"? It's a measure of the extrinsic value, and we end up with a percentage reading-- this percentage is the model for our implied, future returns.

A 20% IV is an annualized reading, which means the market is

expecting the underlying stock to be up 20% or down 20% in 365 calendar days.

This 20% is not a magical number-- it's a statistical approximation of a single standard deviation, again going back to our bell curve.

So the implied volatility is really a 2 standard deviation approximation-- 20% up (1 std dev) and 20% down (1 std dev). That means the market is assigning about a 2/3 chance (+/- 1 std dev) that the annualized return will be within that bell curve area.

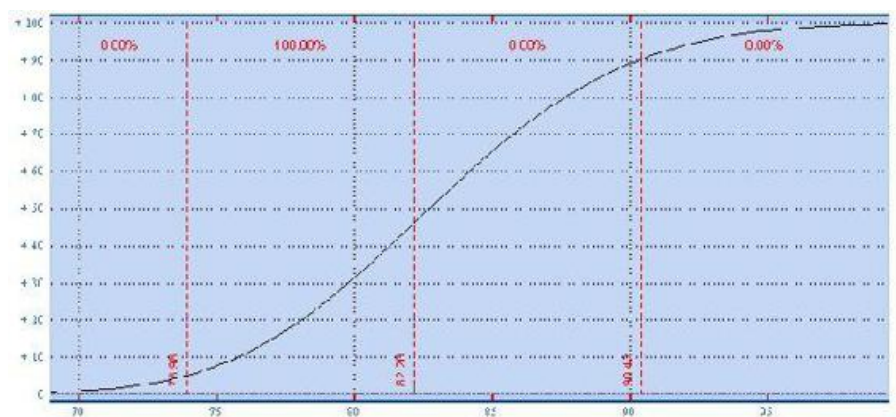
Now let's get back to the whole odds of being in the money.

If a stock is trading at 100, what would be the odds of a 50 call expiring ITM? Very low.

But the 150 call would have very high odds of expiring ITM.

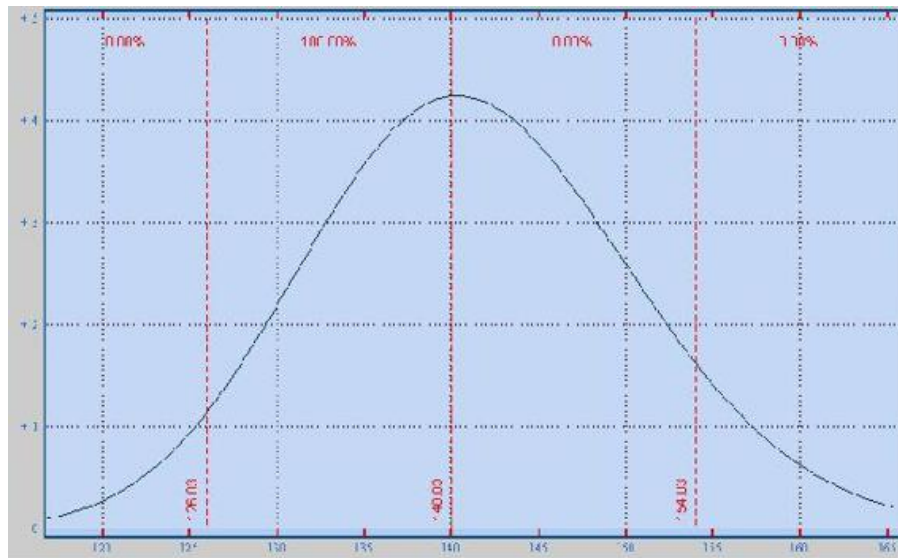
So the low end approaches 0, and the high end approaches 100.

If we graph the delta of all options in a single month, you would get a chart like this:



This is an S-curve, also known as the **cumulative distribution function**. It encases all the odds for a stock of an outcome from 0 to really, really high.

The cumulative distribution function tells us that we are "summing" the outcomes. What happens if we just look at the expected outcomes themselves? Pretty simple, we just look at the incremental change in the CDF and we get something like this:



it brings us back to our big bell curve- this is known as the probability density function of a normal distribution.

And this is really interesting, because the gamma of an option is the first derivative of the delta.

The gamma is mathematically related to the probability density function, and the delta is the integral of the PDF, which turns it into the cumulative distribution function.

Time to expiration and implied volatility in the market drive how wide the bell curve actually is, and it also dictates what the gamma and delta will be as they are derived from the distribution of expected returns on that same bell curve.

Of course we know that markets don't have a uniform distribution of volatility-- market crashes tend to have clusters of high vol, and slow grinding bull markets have clusters of low vol. This is known as "heteroskedasticity" -- what a word! All this means is that volatility tends to cluster.

Knowing that volatility is not homogenous is key when managing risk of really big numbers. That's why institutions tend to use some derivation of a GARCH model when figuring out how much they really have at risk in a market. GARCH stands for "generalized autoregressive conditional heteroskedasticity."

This is far down as I'm willing to take you down the quant rabbit hole, but for more discussions on the heavy math part of things, I will

refer you to the Wilmott Forums.



## APPENDIX C - MY SHAMELESS PLUG

My goal is to make people better option traders. Hopefully I did that with this book.

If you're looking for further, broader help in options trading, there are a few solutions for you to consider.

**InvestingWithOptions** - This is the main website of the IWO Network. There is a blog as well as option trading basics resources for you to read.

**IWO Premium** - This is InvestingWithOption's trading service. We offer a chat room, live webinars, nightly videos, trade alerts, and a model trading portfolio. This is a great opportunity for those who want to go straight into trading options, but need a community of like-minded traders to work with during the day,

**OptionFu** - If you have no pre-existing options trading methodology, this will get you started. This video training course takes you from the very basics to learning how to manage risk in the market as well as developing your own trading systems. I then let you into my trading playbook, showing you the main trades I use on a day to day basis.

## APPENDIX D - FULL DISCLAIMER

The content of this book for educational purposes only. Nothing in this text shall be construed as a solicitation and/or recommendation to buy or sell a security. Trading stocks, options, and other securities involve risk. The risk of loss in trading securities can be substantial. The risk involved with trading stocks, options and other securities are not suitable for all investors. Prior to buying or selling an option, an investor must evaluate his/her own personal financial situation and consider all relevant risk factors. See: Characteristics and Risks of Standardized Options (<http://www.optionsclearing.com/publications/risks/riskstoc.pdf>).

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| How to Visualize Risk               |  |
| Some Common Terms                   |  |
| The Big bell curve                  |  |
| Delta                               |  |
| Gamma                               |  |
| Theta                               |  |
| The Big Tradeoff                    |  |
| Vega                                |  |
| Rho                                 |  |
| The Second Order Greeks             |  |
| Delta - Change Over Price           |  |
| Delta - Change Over Time            |  |
| Delta - Change Over Vol             |  |
| Gamma - Changes Over Price          |  |
| Gamma- Changes Over Time            |  |
| Gamma - Changes Over Vol            |  |
| Theta - Change Over Price           |  |
| Theta - Change Over Time            |  |
| Theta - Change over Volatility      |  |
| Vega - Change Over Price            |  |
| Vega - Change Over Time             |  |
| Volatility - Change Over Volatility |  |
| Putting it All Together             |  |
| Thank You                           |  |
| Appendix A -- Software              |  |
| Appendix B - Some Heavy Math        |  |
| Appendix C - My Shameless Plug      |  |
| Appendix D - Full Disclaimer        |  |